EVIDENCE OF THE MIDDLE-UPPER HURONIAN UNCONFORMITY IN THE QUARTZITE HILLS AT LITTLE LAKE, MICHIGAN

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A critical examination of the exposures of quartzite, quartz slate, and arkose in the hills near Little Lake in T. 45 N., R. 24 W., Marquette County, Michigan, was inspired by the results of recent studies by the senior writer in the Gwinn synclinorium, which lies between five and seven miles west.

The Gwinn synclinorium contains two series of Huronian sedimentary rocks, separated by an unconformity which is characterized by a conglomerate at the base of the upper (Princeton) series containing fragments derived from the various formations (including a productive iron-bearing member) of the lower (Gwinn) series and also from a third sedimentary series not represented in the synclinorium. The work at Little Lake resulted in the identification of an unconformity which, in connection with other data to be described, establishes a basis for correlation of the formations at Little Lake with certain of those in the Gwinn synclinorium.

So far as the writers are aware, no previous mapping and careful study of the rocks at Little Lake has been made. Rominger barely mentions the locality in 1894 in the statement that "iron-bearing rock beds occur in the vicinity of Little Lake."[1] Reference was again made to this locality in 1911 by Van Hise and Leith[2] who correlated the quartzite, quartz slate and arkose in the hills at Little Lake with the Goodrich quartzite or basal member of the Upper Huronian as developed in the Marquette district and the arkose and arkose conglomerate at the base of the Gwinn series in the adjacent Gwinn (Swanzy) synclinorium.

The succession and correlation of the formations in the Gwinn synclinorium and those at Little Lake are given below:

[1] *Michigan Geological Survey*, 1894, Vol. V, Part I, p. 71.

[2] C. R. Van Hise and C. K. Leith, *Monograph 52, U. S. G. S.*, pp. 283-86.

CORRELATION TABLES

GWINN SYNCLINORIUM AND LITTLE LAKE HILLS

	Gwinn-Little Lake District, U.S. Geol. Survey, 1911.	Gwinn District, Mich. Geol. Survey, 1913.	Little Lake Hills, Michigan Geol. Survey, 1913.
Quaternary System	Pleistocene Series—Glacial Deposits.	Pleistocene Series—Glacial Deposits.	Pleistocene Series—Glacial Deposits.
Ordovician System? or Cambrian System?	Unconformity Limestone Sandstone	Unconformity Limestone and sandstone	Unconformity Limestone
Algonkian System—Keweenawan Series	Unconformity	Unconformity Not identified but probably represented by basic dikes which intrude all of the pre-Cambrian formations.	
Huronian Series Upper Huronian	Michigamme slate Bijiki iron bearing member in lenses and layers near base of Michigamme slate. Goodrich quartzite. Quartz slate and quartzite grading down into arkose or recomposed granite.	Michigamme slate, carrying beds of ferruginous slate and chert, quartzite, and graywacke. Conglomerate and graywacke (Goodrich).	Quartz slate and quartzite Conglomerate
Middle Huronian		Unconformity Iron-bearing formation and associated overlying and underlying slate (Negaunee-Siamo). Arkose conglomerate, arkose and quartz slate conglomerate (Ajibik).	Unconformity Conglomerate, arkose, and quartzite
Lower Huronian			
Archean System Laurentian Series Keewatin Series	Unconformity Granite	Unconformity Granite and greenstone, mainly granite	Not exposed near Little Lake Hills. Probably granite

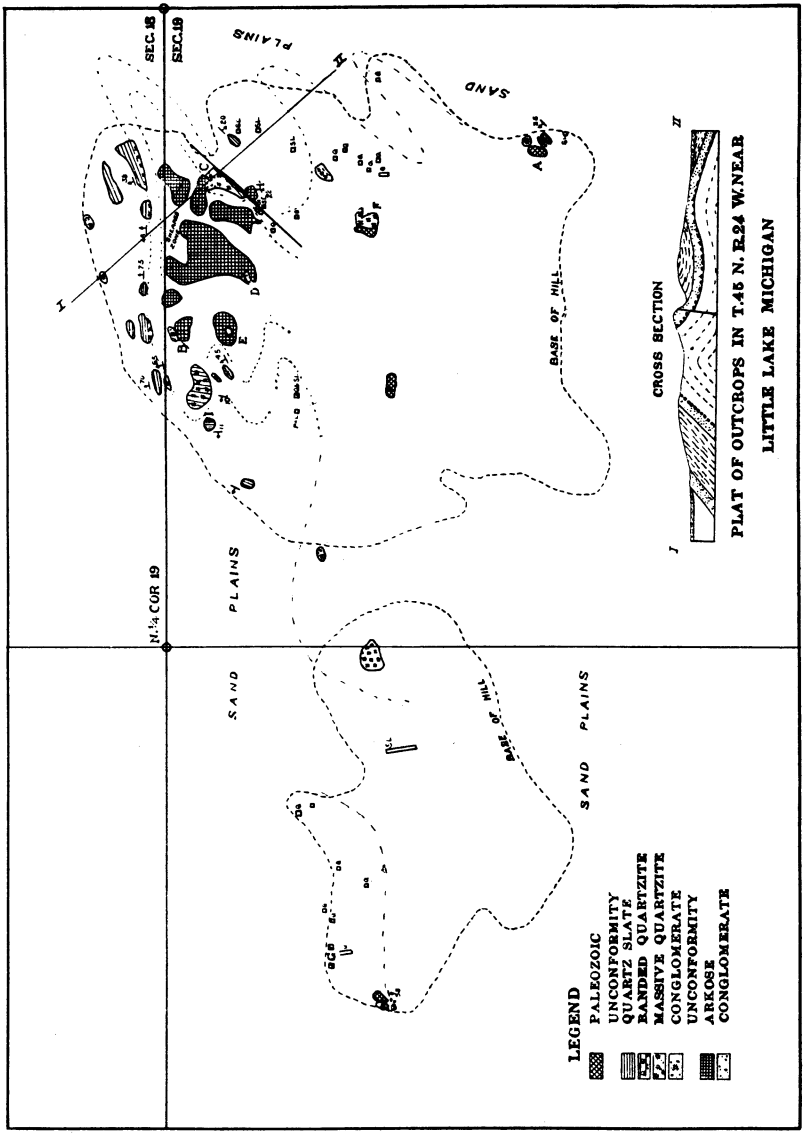
STRUCTURE OF THE LITTLE LAKE HILLS

Rising to a height of possibly 100 feet above a featureless flat sand plain near the station of Little Lake are two hills on which there are many exposures of pre-Cambrian arkose, quartzite, and quartz slate with associated conglomerates. These hills present today, in reference to the fluvio-glacial sand plains in which their bases are buried, somewhat the same appearance that they seem to have had near the close of pre-Cambrian time, when they were monadnocks on a pre-Cambrian peneplain, for remnants of flat lying Paleozoic (Cambrian or Ordivician) limestone still cling to their sides and summits.

The eastern and larger hill is nearly a half-mile in diameter; the western and smaller one is about three-eighths of a mile long in an E.–W. direction with a basal width of about one-eighth of a mile. The exposures are most abundant on the north half of the east hill, but on both hills there are a large number of pits and trenches which were dug many years ago by prospectors whose diligence deserved a better reward than this locality seems to have offered. Aside from the red color of some of the quartz slate beds in the upper series, iron-stained shear zones in the quartzite and arkose, and an exposure at locality *F* (see figure) of about eighteen inches of hematite occupying a lens-shaped cavity along a zone of thrust faulting in massive quartzite, there appears no present evidence of the attractiveness which these hills seem to have presented to the early prospector for iron ore.

The structure of the north side of the east hill is apparently an anticline, the crest of which has been cut away by erosion, thus exposing the arkose and associated conglomerate of the lower (Gwinn) series flanked on the north, east, and west sides by conglomerate, quartzite, and quartz slate of the upper (Princeton) series. This is the only complete structural feature which can be determined from the available data. There is evidence in the development of cleavage and schistose structures, shear zones and faults of both normal and thrust type, that general deformation has been severe. Further evidence of the intensity of deformation is afforded in the overturning of the formations, with consequent apparent reversal in succession, in exposures at locality *A* at the

southeast extremity of the east hill. While evidence of minor faulting is abundant in outcrops and pits, it is found impossible



with information available to trace the course or measure the throw of any of these faults. The fault at locality *C-H* is a partial

exception but the only thing known about this fault is its direction and the fact that its vertical displacement is inconsiderable. In reference to the structure of the west hill perhaps no inferences are warranted. So far as known, the arkose of the lower series is not exposed but the distribution of the lower and higher members of the upper series together with the topographic expression faintly suggests a shallow syncline trending across the hill in a N.E.–S.W. direction carrying the quartz slate member in the trough and exposing the underlying quartzite on its opposite flanks. But the structure is probably not so simple as this for there is evidence of faulting in some of the pits.

THE LOWER (GWINN) SERIES

Arkose and conglomerate.—The major portion of the arkose formation is in reality now an abundantly sericitic quartzite, the sericite being a metamorphic derivative of the original feldspar. The abundance of sericite affords on cleavage surfaces, a characteristic pearly luster. From the dominant phase there are gradations through intermediate phases to typical arkose with feldspar practically unaltered. Of subordinate importance are interstratified lenses of conglomerate varying from a foot or two up to eight feet in thickness. The pebbles are mainly vein quartz well rounded and of various sizes under four inches in diameter. Other pebbles of dense, vitreous, gray quartzite, black chert, and siliceous dolomitic slate are much less abundant. The matrix of the conglomerate beds has the composition of quartzite rather than arkose and is usually dark, dense, vitreous, and slightly sericitic.

Bedding structure is not observable in any of the various phases of the formation, except as it may be represented by an occasional thin layer of gray chert. The deposition of these cherty layers probably heralded the approach of a change in conditions of sedimentation represented by an iron-bearing member in the adjacent Gwinn synclinorium which lies in part directly on a similar arkose-conglomerate formation. At Little Lake the iron-bearing member appears to have been removed by erosion prior to the deposition of the overlying conglomerate and quartzites. The

similarity of the arkose-conglomerate of Little Lake to that at the base of the Gwinn series extends to the pebble content. Rounded fragments of dolomitic siliceous slate, and gray quartzite are common to both localities, but the bowlders of granite and green schist which occur in the conglomerate of the Gwinn district were not observed in the exposures at Little Lake.

UPPER (PRINCETON) SERIES

The upper series, so far as represented at Little Lake, comprises a higher horizon of red- and gray-banded quartz slate and slaty quartzite grading down through banded quartzite and massive non-bedded quartzite into a basal conglomerate.

Conglomerate.—The contact of the upper and the lower series is exposed at localities *B* and *C* (see figure). At locality *B* this contact is distinguishable only on careful examination. The base of the upper series on weathered exposures is not conspicuously dissimilar to the underlying arkose except on freshly fractured surfaces which reveal, in contradistinction to the underlying sericitic, quartz-feldspar rock, a dense, hard matrix of quartzite holding pebbles of vein quartz of sizes less than an inch in diameter. At locality *C*, however, all doubt of the unconformable relations of the arkose-conglomerate and the overlying series is dispelled. The change from arkose to dense, black, vitreous quartzite is abrupt at a wavy contact of knife-like sharpness. In addition to the quartz pebbles observed at locality *C* there are pebbles of chert and large bowlders of the underlying arkose above one foot in diameter. The arkose bowlders are much softer than the embedding matrix of quartzite and weather out to form characteristic pit-like depressions. The full thickness of the basal conglomerate is not exposed at locality *C*, but at locality *B* it is apparently only six feet. At *C* only about four feet are observable.

Quartzite and quartz slate.—There are three distinct main phases of this series, viz., (1) a massive phase associated with the basal conglomerate, grading upward into (2) a banded phase which in turn is over-lain rather sharply by (3) beds of gray- and red-banded quartz slate. Although these three phases correspond to definite stratigraphic horizons, considerable difficulty is experienced in

correlating the various exposures of the different members of this series. The chief difficulties refer to the relation of the quartzite on the west hill to that exposed on the east hill and to the determination of the stratigraphic position of the two outcrops of quartzite north of the slate at the base of the east hill. The outcrops of gray quartz slate and red-banded quartz slate on the north slope of the west hill are apparently stratigraphically above the exposures of quartzite in outcrops and pits on its northwest and northeast sides. Whether the quartzite at the base of the north slope of the east hill is stratigraphically above the quartz slate or represents the underlying massive quartzite brought up by faulting cannot be determined.

Extended description of the different phases of the quartz rocks in the upper series has little interest for present purposes. The dissimilarities of the different members refer mainly to texture and bedding structures rather than to composition. The red color of certain layers in the quartz slates is caused by the presence of small particles of finely disseminated hematite.

Notes on the correlation.—In a former paper the senior writer discussed the importance of the unconformity separating the Princeton (upper) and Gwinn (lower) series in the Gwinn synclinorium and adduced evidence in support of the correlation of these two series with the Upper and Middle Huronian. The lithologic similarity of the arkose-conglomerate formation at Little Lake to the basal member of the Gwinn series, only a few miles distant, considered in connection with the unconformity separating it from the overlying quartzites and quartz slates is a sufficient basis for extending the arguments for the correlations in the Gwinn district to cover the two unconformable series at Little Lake. The geology of each area accounts for three unconformable series of sedimentary rocks corresponding to the Lower, Middle, and Upper Huronian of the adjacent Marquette district. The upper two series are present while the lower one is represented in both areas by fragments of some of its formations in the base of the middle series.

The absence in the lower series at Little Lake of the slate and iron formation members developed in the Gwinn synclinorium

strengthens the evidence of the importance of the erosion interval which intervened between the deposition of the Princeton and Gwinn series. Incidentally it has a practical bearing on the possibilities for success attendant on drilling for iron ore in the immediate vicinity of the Little Lake Hills. Some drilling, of which the writers have no records, has already been done and we understand that additional drilling is contemplated by parties who are likewise ignorant of the results of the former explorations.